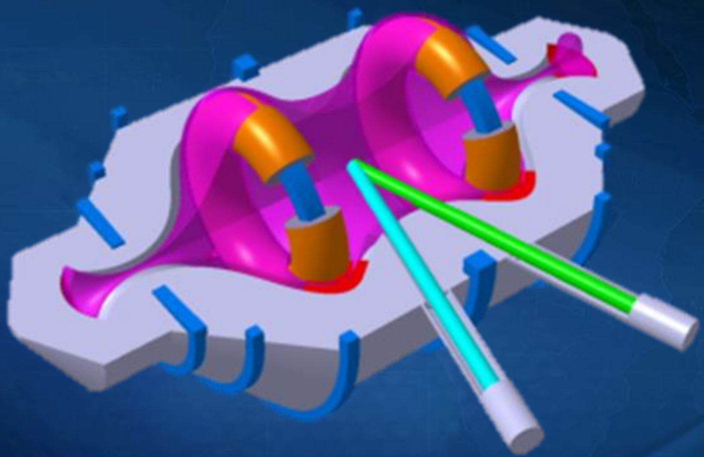
Compact Fusion Reactor - CFR



Overview, Status And Development Plan

28 August 2017

LOCKHEED MARTIN

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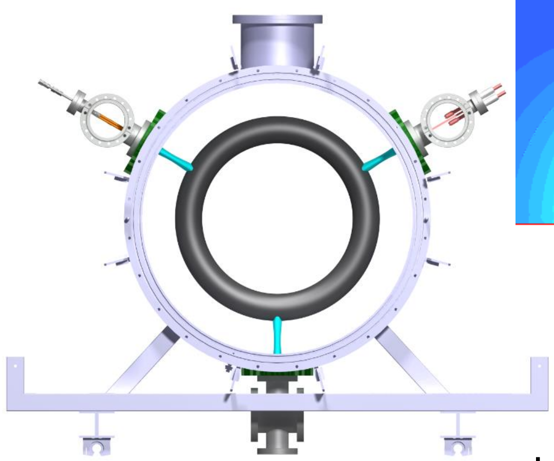
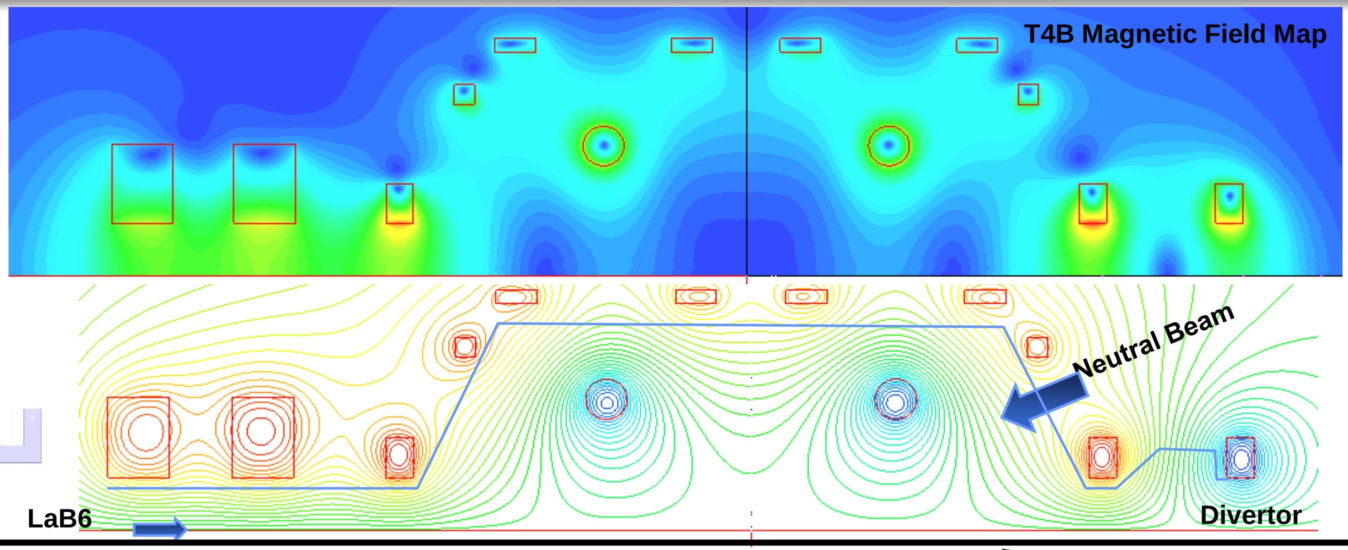
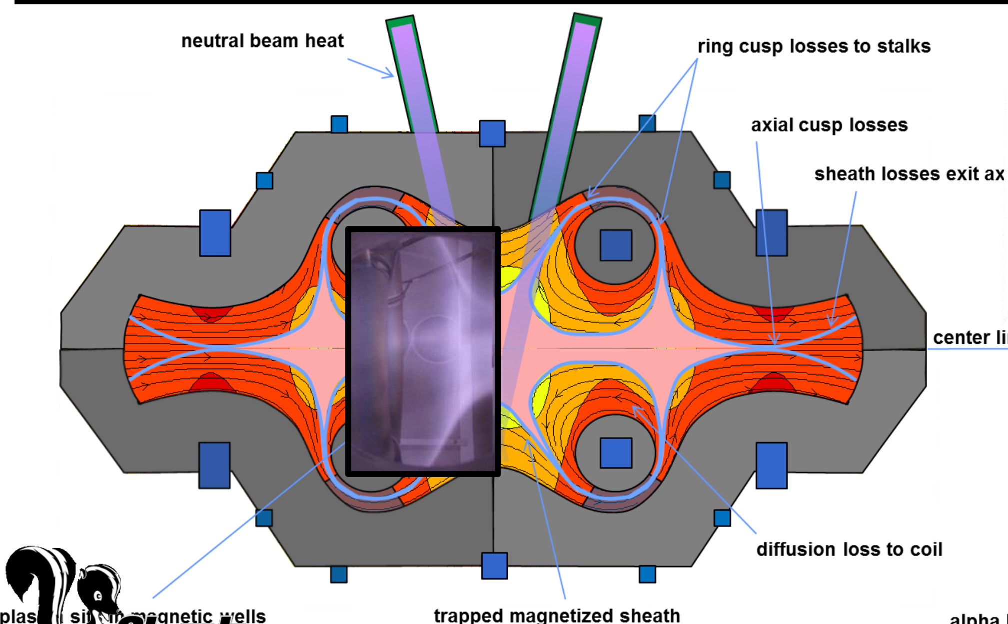
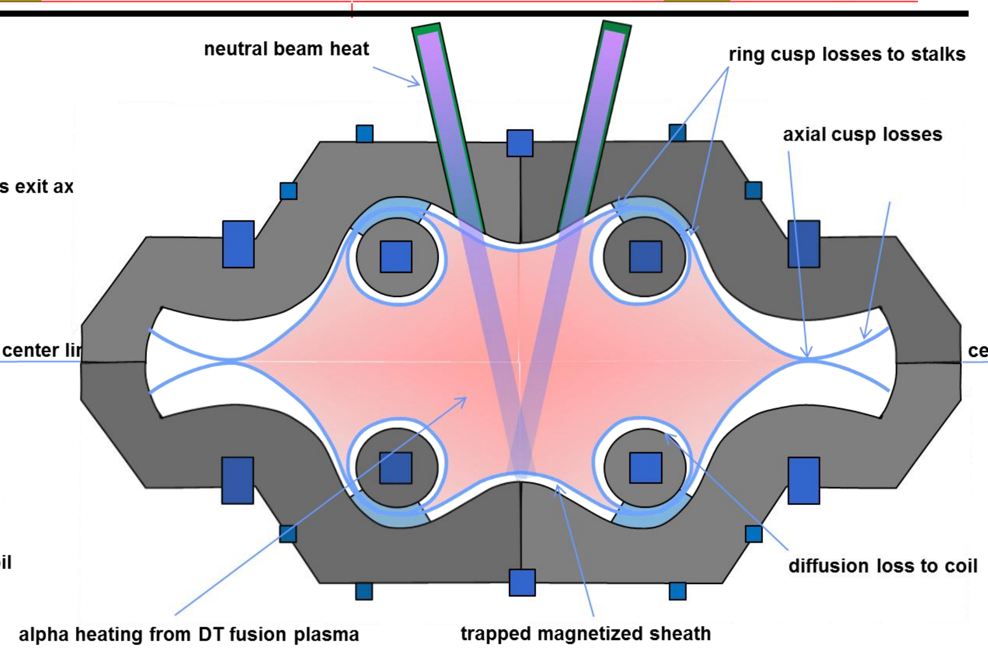
CFR –Diamagnetic Sheath Confinement

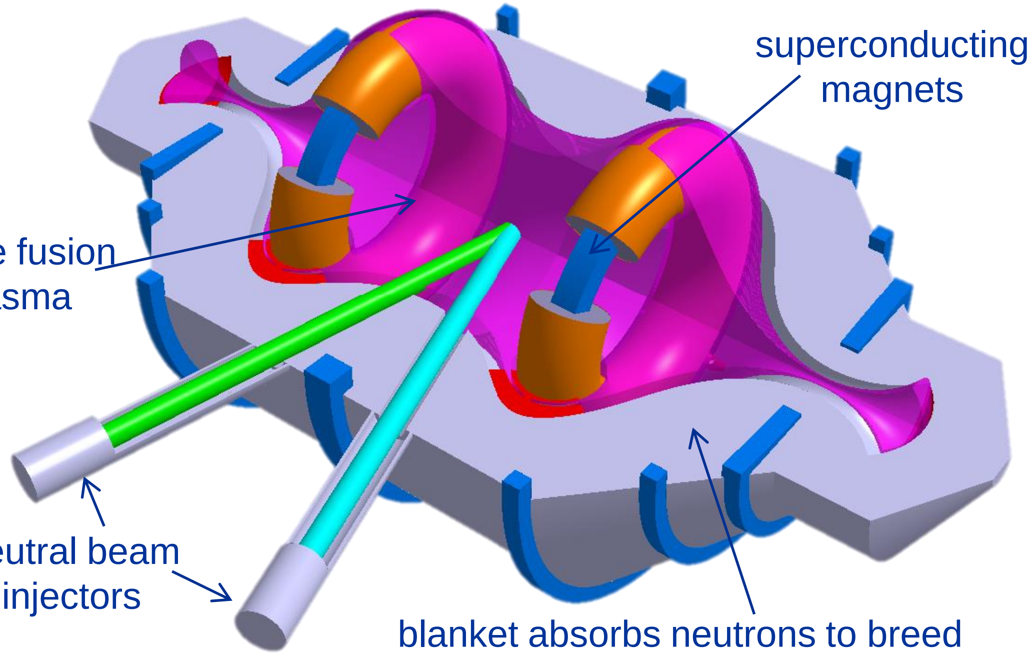








CFR - Compact Fusion Reactor Concept



100 MW electric output - 80,000 homes

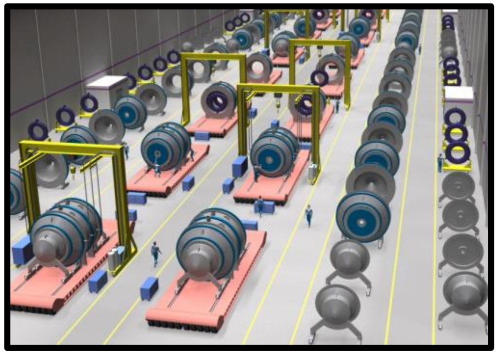
Compact and elegant, 15.5 m X 6.5 m OD

200-1000 metric tons

Cheap and safe to build and operate

Burns < 20 kg DT fuel/year

Applications



TX

LCS-1

C-5

CFR - Systematic Development Plan

Ultimate goal: Achieve reactor conditions

T5 Goal: Show plasma heating and inflation, measure sheaths and losses

- Demo high density plasma source
- Demo neutral beam capture / confinement
- Measure sheath size, cusp losses
- Characterize kinetic and fluid instabilities

T6 High temperature experiment

- Magnetic shielding of stalks
- High field superconducting coil design

T7 DD reactor conditions demonstration

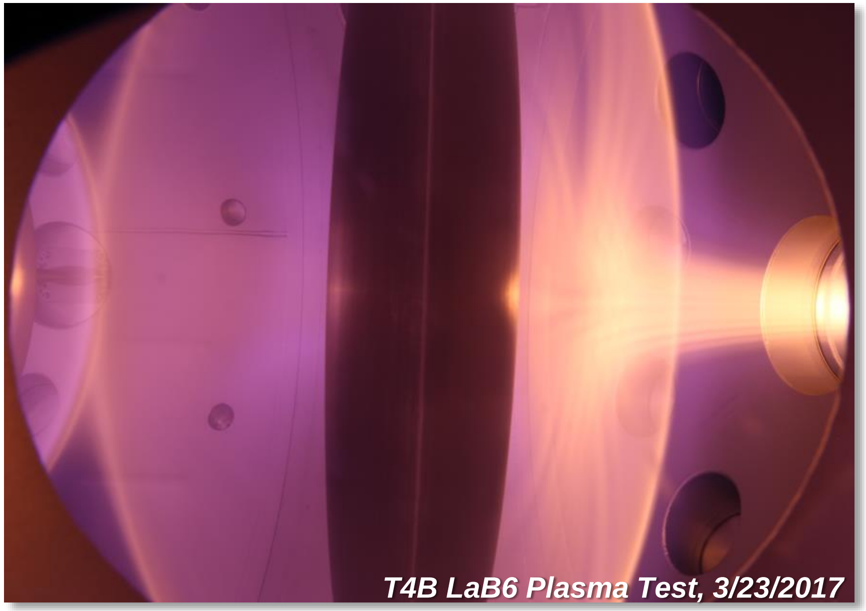
- Full power and size

T8 DT ignited reactor demonstration

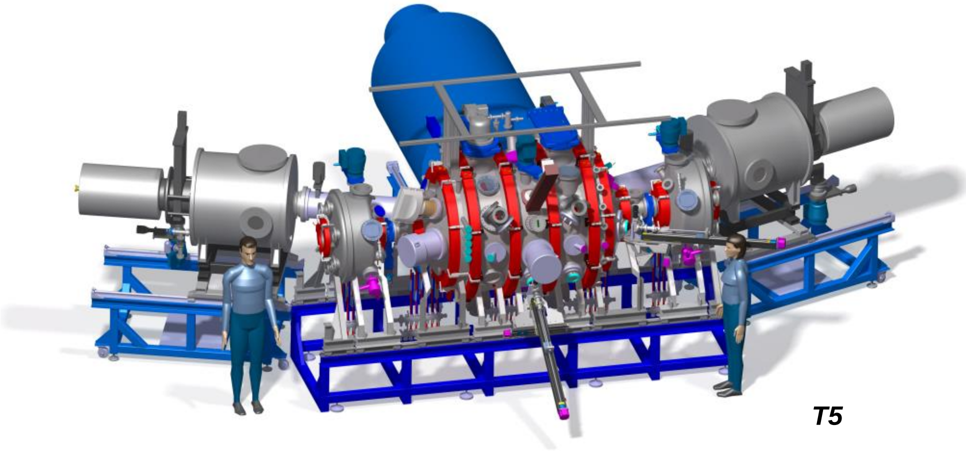
- Alpha product confinement / stability

TX reactor development

- Modular, survivable blanket
- Tritium breeding and processing
- Robust subsystems development
- Regulatory regime and deployment



T4B LaB6 Plasma Test, 3/23/2017



T5

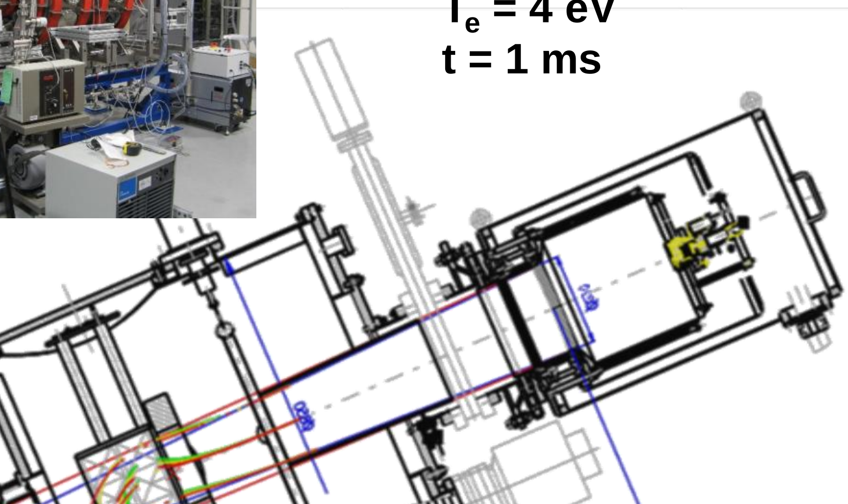
CFR - T4B Heating Experiment

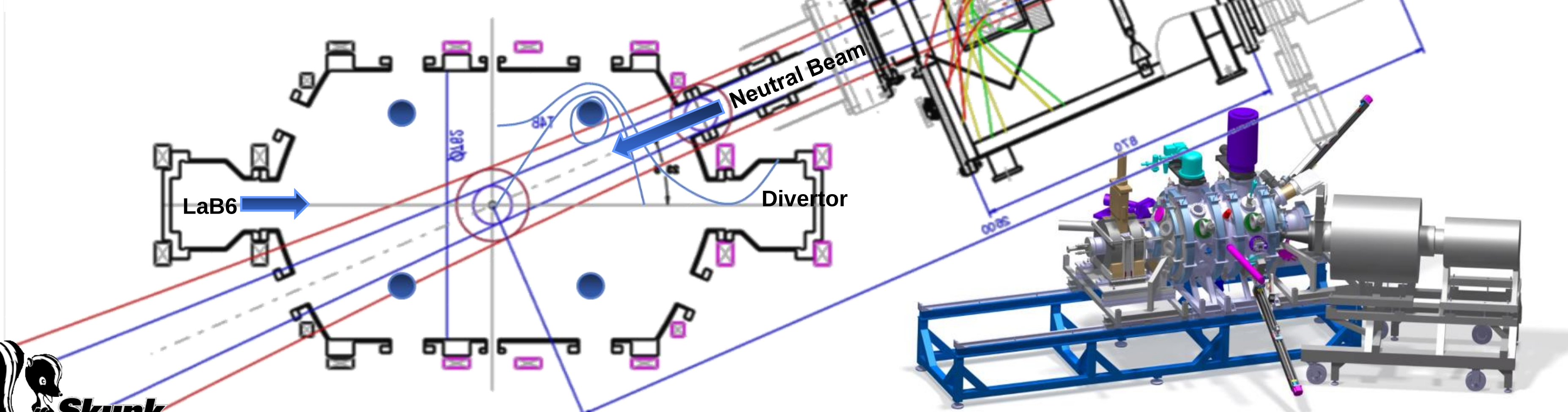
Experiment parameters

- B_p = 0.1 T, vacuum plasma edge field
- B_{ring} = 0.23 T, MR_{ring} = 1.3
- B_{mirror} = 0.47, MR_{mirror} = 2.6
- V = 0.2 m^3
- E = 1170 J, plasma energy at high Beta
  - P_{in} = 500 kW -> τ >2.3 ms
- Source/target predicted parameters:
  - n = $5{\cdot}10^{19}$ m^{-3}, T_e = 5 eV, E = 12 J, P ~ 150 kW -> t = 80 μs
- Heating predicted parameters:
  - n = $5{\cdot}10^{19}$ m^{-3}, (T_e = 200 eV, T_i = 120 eV at high Beta)
  - 18 ms energy confinement time
- P_{heat} = 500 kW should be sufficient to get high Beta
  - Over 3 ms, E_{in} = 1500 J
  - t_{fie} = 13 μs @ T_e = 10 eV t_{fie} = 1.8 ms @ T_e = 250 eV
- ρ_i = 6.7 mm @ T_i = 75 eV fits well within field geometry
  - 3.7 cm minimum gap between ring cusp null line and wall

Source Parameters

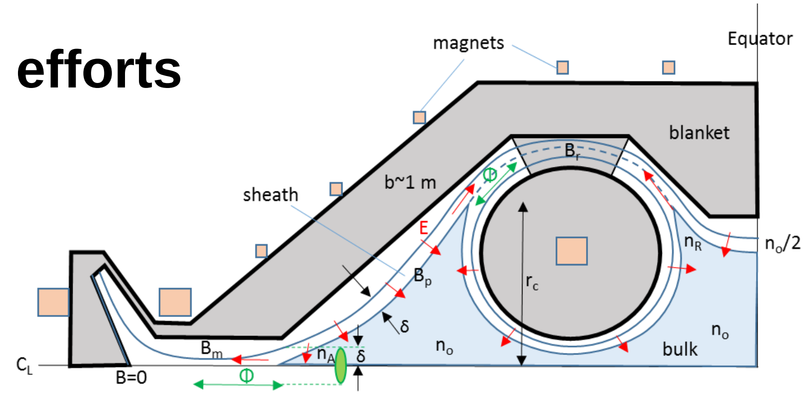
P_{LaB6} = 70 kW
n_e > $2{\cdot}10^{19}$ m^{-3}
T_e = 4 eV
t = 1 ms





CFR - Acceleration Opportunities

Potential accelerator and collaborative efforts

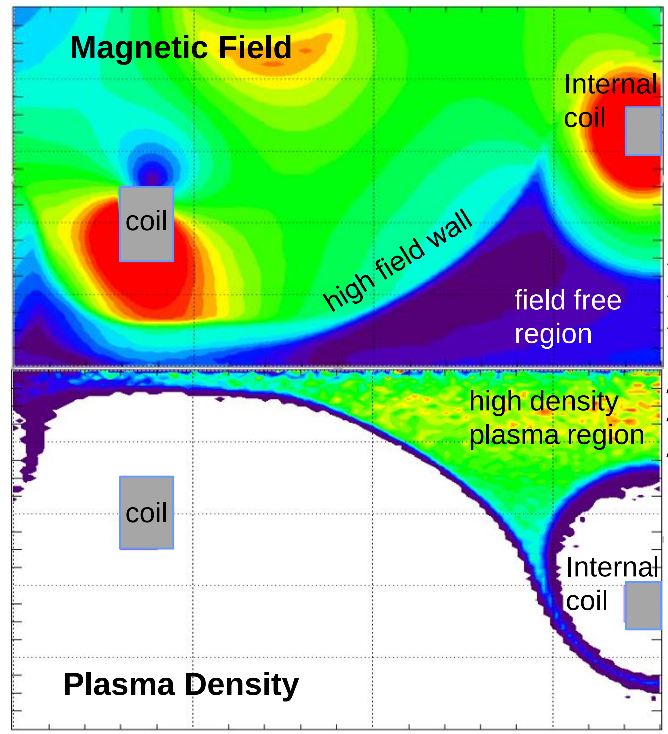


Fusion Physics Demonstration

- ***Modeling and predictive capabilities***
- ***Source development***
- ***Diagnostics***
- ***Neutral beam development***
- ***Internal coil support magnetic shielding***

Fusion Engineering Development

- ***High temperature superconducting coils***
- ***Blanket and power plant concept design***
- ***Tritium regulatory planning***
- ***Reactor material development***



LSP code
RZ domain
10 cm x 18 cm
0.5 mm grid
2M particles
400 ns
20 processors
72 hr run

CFR – The Path to Clean, Unlimited Energy

- CFR concept - efficient & stable magnetic confinement
- Rapid design cycles build toward self-heating system and 100 MW_e scale power plants in 2020s
- Results to date are promising - stable cold, dense target plasma suitable for neutral beam heating
- Upcoming heating experiments will investigate transition to high beta, sheath mode of confinement
- Modeling, diagnostics, and long lead subsystems are good opportunities for collaboration and parallel development to accelerate progress

Skunk Works